

TITLE OF THE INVENTION  
IMAGE DISPLAY SYSTEM, INFORMATION PROCESSING APPARATUS,  
AND METHOD OF CONTROLLING THE SAME

5 BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a stereoscopic  
display apparatus which allows an observer to observe  
10 a stereoscopic image by using the parallax between the  
right and left eyes, an information processing  
apparatus, a host computer for controlling the display  
apparatus, and a method therefor, thereby providing an  
operation environment for comfortable stereoscopic  
15 display.

RELATED BACKGROUND ART

In general, a stereoscopic image display  
apparatus of the parallax barrier scheme is known well  
20 as an apparatus for displaying a stereoscopic image.  
The parallax barrier scheme is disclosed in  
S. H. Kaplan, "Theory of Parallax Barriers.", J. SMPTE,  
Vol. 59, No. 7, pp. 11 - 21 (1952). According to this  
scheme, a striped image obtained by alternately  
25 arranging at least right and left images of a  
plurality of parallax images from a plurality of

viewpoints into a vertically striped pattern is observed through a slit pattern (called a parallax barrier) having predetermined opening portions placed at a predetermined distance from this image. With this operation, the observer observes images corresponding to the respective eyes with the corresponding eyes. Japanese Patent Laid-Open Nos. 3-119889 and 5-122733 disclose stereoscopic display apparatuses in which a parallax barrier is electronically generated by a transmission type liquid crystal display device and the like, and the shape and position of each stripe are variably controlled to improve the compatibility with conventional 2D image display apparatuses.

Fig. 19 shows the basic arrangement of the stereoscopic image display apparatus disclosed in Japanese Patent Laid-Open No. 3-119889. This stereoscopic image display apparatus includes a transmission type liquid crystal display apparatus 101 for displaying images and an electronic parallax barrier 103 constituted by a transmission type liquid crystal display placed on the liquid crystal display apparatus 101 sandwiching a spacer 102 having a thickness  $d$ .

The transmission type liquid crystal display apparatus 101 displays a vertically striped image consisting of parallax images sensed from two or more

directions. A parallax barrier pattern is formed at an arbitrary position on the barrier surface of the electronic parallax barrier 103 upon designation of X and Y addresses by a control means such as a

5 microcomputer, thereby allowing a stereoscopic vision based on the principle of the above parallax barrier scheme. Note that when this electronic parallax barrier is made colorless and transparent throughout the entire image display area, a 2D image can be  
10 displayed, thus realizing the compatibility between the 2D display and 3D display.

An apparatus capable of performing mixed display of 3D and 2D images within a single frame is disclosed in Japanese Patent Laid-Open No. 5-122733. In this  
15 apparatus, as shown in Figs. 20A and 20B, a striped barrier pattern can be generated only in a partial area of the electronic parallax barrier 103.

The lenticular scheme is also known widely as a means for displaying a stereoscopic image by using the  
20 parallax between the right and left eyes of an observer as in the parallax barrier scheme. In the lenticular scheme, a lenticular lens constituted by an array of many semicylindrical lenses is placed on the front surface of a display to spatially separate an  
25 image into images for the right and left eyes, thereby allowing the observer to observe a stereoscopic image.

In the display of the lenticular scheme as well, an image displayed on the screen is a vertically striped image obtained by alternately arranging right and left images.

5       As a stereoscopic display using a horizontally striped image obtained by alternately arranging right and left images, Cyberbook (trademark) is available from Vrex Inc. In this display, as shown in Fig. 21, a striped polarizing plate 202 obtained by alternately  
10       arranging two types of polarizing plates, whose polarization axis directions are perpendicular to each other, in units of horizontal lines is placed on the front surface of the liquid crystal display of a notebook personal computer 201. A displayed image is  
15       observed through polarization glasses 203 having the two types of polarizing plates corresponding to those used for the striped polarizing plate 202 arranged for the right and left eyes. (In Fig. 21, the arrows indicate polarizing direction of the polarizing  
20       direction of the polarizing plates.) With this arrangement, of the displayed image, lines to be seen with the right and left eyes of the observer can be separated/selected. For example, the odd lines of the liquid crystal display are used <sup>as</sup> right-eye image  
25       display lines, and the even lines are used as left-eye image display lines to allow the observer to

separately observe images formed by the respective lines with the corresponding eyes.

Various environments in which 3D displays are used can be conceived. Assume that an entire screen is  
5 occupied by a single type of image as in the case of a television set. In this case, the relative positional relationship between a displayed image and each constituent element of the apparatus always remains the same. Once, therefore, the observer sets his/her  
10 eyes at an optimal observation position, he/she can continuously obtain a proper stereoscopic vision. Assume that a plurality of windows are opened on one screen, and images are to be displayed in the respective windows like images handled in a computer.  
15 In this case, as the positions of the windows change, the relationship between each image and each constituent element of the apparatus changes. As a result, the optimal observation position changes, and hence the observer cannot always obtain a proper  
20 stereoscopic vision.

When, for example, a barrier 1 of the parallax barrier scheme and a striped image 2 displayed on the image display apparatus maintain a proper relative positional relationship, as shown in Fig. 22, light  
25 forming an image for the left eye propagates to a left eye 3, and light forming an image for the right eye

propagates to a right eye 4. As a result, the observer can properly recognize a stereoscopic image.

If, however, the relative positions of the barrier 1 and the striped image 2 displayed on the image display apparatus are shifted by one pitch in the horizontal direction with respect to the positions in Fig. 22, as shown in Fig. 23, light forming an image for the left eye propagates to the right eye 4, and light forming an image for the right eye propagates to the left eye 3. As a result, a "reversed stereoscopic vision" for the observer is produced.

When a plurality of windows are opened, and stereoscopic images are displayed in the respective windows, in particular, stereoscopic visions may be properly produced in some windows, but reversed stereoscopic visions may be produced in other windows.

When windows are opened, and images are displayed in the respective windows in this manner, since the relative positions of the barrier 1 and the striped image 2 are likely to change, the possibility of the occurrence of a reversed stereoscopic vision is high. This tendency applies to any stereoscopic display scheme, as well as the parallax barrier scheme, in which the relative positional relationship between a displayed image and other optical parts is important.

The same applies to Cyberbook available from Vrex,

which uses a "horizontally striped" parallax image as a striped image. In this case, when, for example, the relative positions of a striped polarizing plate and a striped image displayed on the image display apparatus  
5 are shifted by one pitch in the vertical direction, a reversed stereoscopic vision is produced.

#### SUMMARY OF THE INVENTION

The present invention has been made in  
10 consideration of the above problems, and has as its object to provide an image display system and an information processing apparatus which can always allow a proper stereoscopic vision by controlling the arrangement of the stripe parallax images of a  
15 stereoscopic image displayed in a window to be suited to a display apparatus, and a method of controlling the system and the apparatus.

It is another object of the present invention to provide an information processing apparatus and method  
20 which can always allow an observer to have a proper stereoscopic vision even with a change in the position of each window when several windows are opened on the screen, and images are displayed in the windows like images handled in a computer.

25 It is still another object of the present invention to allow a stereoscopic vision in units of

windows.

It is still another object of the present invention to always allow a proper stereoscopic vision without changing the contents displayed in a window.

5 It is still another object of the present invention to always allow a proper stereoscopic vision without changing the display position of a window.

It is still another object of the present invention to allow a proper stereoscopic vision while  
10 a window is moved.

According to an aspect of the present invention, in order to achieve the above objects, there is provided an image display system capable of performing stereoscopic display, comprising stereoscopic image  
15 display means for displaying a stereoscopic image having stripe parallax images arranged for right and left eyes, stereoscopic vision control means for controlling directivity of the stereoscopic image such that stripe images of the stereoscopic image are  
20 respectively observed with the right and left eyes, and changing means for, when a relative positional relationship between the stereoscopic image and the stereoscopic vision control means is not a proper relationship with which an observer can obtain a  
25 proper stereoscopic vision, changing the relative positional relationship to realize a proper



stereoscopic vision.

According to another aspect of the present invention, there is provided an information processing apparatus which can be connected to an image display

5 apparatus having stereoscopic vision control means for controlling directivity of a stereoscopic image to allow an observer to observe stripe images of the stereoscopic image with right and left eyes of the observer, respectively, comprising generation means

10 for generating image data including a window in which stripe parallax images corresponding to the right and left eyes are arranged, determination means for determining whether a relative positional relationship between the window and the stereoscopic vision control

15 means of the image display apparatus is a proper positional relationship which allows a proper stereoscopic vision, and adjustment means for, when the determination means determines that the relationship is not the proper relationship which

20 allows a proper stereoscopic vision, adjusting the relative positional relationship to allow a proper stereoscopic vision.

According to still another aspect of the present invention, there are provided control methods for the

25 above image display system and information processing apparatus.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate  
5 the same or similar parts throughout the figures thereof.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated  
10 in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 is a block diagram showing the arrangement  
15 of a computer system according to the first embodiment of the present invention;

Fig. 2 is a view showing an image for the left eye;

Fig. 3 is a view showing an image for the right  
20 eye;

Fig. 4 is a view showing a vertically striped parallax image obtained by dividing the parallax images in Figs. 2 and 3 into vertical stripes, and alternately arranging them;

Fig. 5 is a view showing a horizontally striped parallax image obtained by dividing the parallax  
25

images in Figs. 2 and 3 into horizontal stripes, and alternately arranging them;

Fig. 6 is a view showing a state in which the positions of right and left stripe images defined by a  
5 directivity control means in accordance with the display position of a window for displaying a stereoscopic image coincide with the right and left stripes of the stereoscopic image;

Fig. 7 is a view showing a state in which the  
10 positions of right and left stripe images defined by a directivity control means in accordance with the display position of a window for displaying a stereoscopic image do not coincide with the right and left stripes of the stereoscopic image;

Fig. 8 is a flow chart showing an operation  
15 procedure performed by a host computer in the first embodiment;

Fig. 9 is a view for explaining fine adjustment  
20 of a window position for a vertically striped parallax image;

Fig. 10 is a view for explaining fine adjustment  
of a window position for a horizontally striped parallax image;

Fig. 11 is a flow chart showing an operation  
25 procedure performed by a host computer in the second embodiment of the present invention;

Fig. 12 is a view for explaining how the contents of a displayed image in a window are changed in the second embodiment;

Fig. 13 is a view for explaining how the contents  
5 of a displayed image in a window are changed in the second embodiment;

Fig. 14 is a view for explaining how the contents of a displayed image in a window are changed in the second embodiment;

10 Fig. 15 is a view for explaining how the contents of a displayed image in a window are changed in the second embodiment;

Fig. 16 is a view for explaining how the contents of a displayed image in a window are changed in the  
15 second embodiment;

Fig. 17 is a flow chart showing a control procedure performed by a host computer in the third embodiment of the present invention;

Fig. 18 is a flow chart showing a control  
20 procedure for preventing a reversed stereoscopic vision during a window dragging operation in the fourth embodiment of the present invention;

Fig. 19 is a view showing the basic arrangement of the stereoscopic image display apparatus disclosed  
25 in Japanese Patent Laid-Open No. 3-119889;

Figs. 20A and 20B are views for briefly

explaining the stereoscopic image display apparatus disclosed in Japanese Patent Laid-Open No. 5-122733;

Fig. 21 is a perspective view for briefly explaining a stereoscopic image display apparatus using Cyberbook (trademark);

Fig. 22 is a view showing a state in which the relative positions of a barrier and a striped image in the parallax barrier scheme have a proper relationship; and

Fig. 23 is a view showing a state in which the relative positions of the barrier and the striped image in the parallax barrier scheme have an improper relationship.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail in accordance with the accompanying drawings.

##### <First Embodiment>

Each of the following embodiments will exemplify a stereoscopic display apparatus for allowing an observer to observe a stereoscopic image by using the parallax between the right and left eyes and a computer system including a host computer for controlling the stereoscopic display apparatus.

Fig. 1 is a block diagram showing the arrangement

of a computer system according to the first embodiment. Referring to Fig. 1, reference numeral 10 denotes a host computer; 20, a stereoscopic display apparatus; 11, a CPU for realizing various types of control operations performed by the host computer 10; 12, a ROM storing a boot program, which is executed when the CPU 11 is started, and various types of data; and 13, a RAM which serves as a main memory for storing control programs executed by the CPU 11 and provides a work area used when the CPU 11 executes various types of control operations. Reference numerals 14 and 15 respectively denote a keyboard and a pointing device, which are used to input commands from the user. Reference numeral 16 denotes an external memory such as a hard disk, which is used to store various application programs and data. Note that each application program stored in the external memory 16 is loaded into the main memory area of the RAM 13 when it is executed by the CPU 11. Reference numeral 17 denotes a display interface, which is connected to the stereoscopic display apparatus 20 in this embodiment; and 18, a bus for connecting the respective components of the host computer 10 to each other.

The stereoscopic display apparatus 20 includes an interface 21 for receiving a video signal and position information indicating a stereoscopic display position

from the host computer 10. Note that the video signal and the position information are respectively supplied to drivers 22 and 23. The driver 22 controls a transmission type liquid crystal display 101 of the stereoscopic display apparatus on the basis of the input video signal to display an image corresponding to the video signal. The driver 23 controls an electronic parallax barrier 103 on the basis of the input position information to display a parallax barrier pattern in the stereoscopic display area indicated by the position information. Note that the transmission type liquid crystal display 101 and the electronic parallax barrier 103 are the same as those described with reference to Fig. 19. When the electronic parallax barrier 103 is driven, the stripes of the parallax barrier pattern are formed at fixed positions. That is, the display area for the barrier pattern is controlled in accordance with position information, but the positions at which the black stripes can be produced are fixed.

The communication unit constituted by the above interfaces 17 and 21 transmits the above video signal and position information. This communication unit may be a combination of a conventional video interface and serial interface (RS232C or the like) or a dedicated interface. In addition, the dedicated interface may

use unused connector pins of a conventional video interface.

Note that above video signal includes both a general 2D image and a 3D image allowing a

5 stereoscopic vision (e.g., the above striped image constituted by two types of parallax images). In this embodiment, 2D and 3D images are displayed in units of windows. In addition, the above position information indicates the size and position of the area in which  
10 the above stereoscopic image is present. If, therefore, a parallax barrier pattern is displayed in the area, of the electronic parallax barrier 103, which is indicated by position information, and the image based on a video signal is displayed on the transmission  
15 type liquid crystal display 101, the 3D image contained in the video signal can be stereoscopically viewed, and the general 2D image can be properly displayed.

In this embodiment, an apparatus using the  
20 parallax barrier scheme will be mainly described. As is obvious, however, the present invention can also be applied to the Cyberbook (trademark) scheme described with reference to Fig. 21. Note that the Cyberbook scheme does not require the above position information  
25 because the host computer 10 and the stereoscopic display apparatus 20 are integrated.



In a stereoscopic display apparatus designed to allow the observer to observe a stereoscopic image by using the parallax between the right and left eyes, the images to be displayed on the image display screen

are roughly classified into two types, i.e., a vertically striped parallax image and a horizontally striped parallax image. These images will be further described below. For example, Fig. 2 shows an image for the left eye; and Fig. 3, an image for the right eye. A vertically striped parallax image is obtained by dividing the images in Figs. 2 and 3 into vertical stripes, and alternately arranging and synthesizing them. A horizontally striped image is obtained by dividing the images in Figs. 2 and 3 into horizontal stripes, and alternately arranging and synthesizing them (referring to Figs. 4 and 5, reference symbols L and R denote images for the left and right eyes, respectively).

Each striped image can be divided into right and  
20 left images when combined with a directivity control  
means such as a barrier, a lenticular lens, or a  
striped polarizing plate. If, however, the directivity  
control means and a striped image are not set at  
proper relative positions, the right and left images  
25 are not observed with the corresponding eyes, as  
described with reference to Figs. 22 and 23. Since the

directivity control means is a component incorporated in the stereoscopic display apparatus, the position of the means is basically fixed. In general, when an image is to be handled in a computer, a window which  
5 can be moved to an arbitrary position is opened, and the image is displayed in the window. For this reason, the directivity control means and the striped image may not be set at proper relative positions depending on the position of the window.

- 10 Assume that in a stereoscopic display apparatus using vertically striped parallax images, right-eye strip images (the areas indicated by "R" and surrounded with the solid lines in a window 6) are superimposed on the right-eye image display areas (the  
15 areas indicated by "R" and surrounded with the dotted lines in a screen 7) of the directivity control means (coinciding with the screen 7 when viewed from the front surface side), as shown in Fig. 6. In this case, the observer can obtain a proper stereoscopic vision.
- 20 In contrast to this, assume that the window 6 for displaying an image is located at the position in Fig. 7 within the screen 7, and the right-eye strip images (the areas indicated by "R" and surrounded with the solid lines in the window 6) are superimposed on  
25 the left-eye image display areas (the areas indicated by "L" and surrounded with the dotted lines in the

screen 7) of the directivity control means. In this case, the observer cannot obtain a proper stereoscopic vision, but has a reversed stereoscopic vision (the left-eye image is seen with the right eye, and the right-eye image is seen with the left eye).

To eliminate this inconvenience, in this embodiment, the following control is performed by the computer. Fig. 8 is a flow chart showing an operation procedure performed by the host computer in the first embodiment. In step S10, the host computer 10 detects that a window for stereoscopic image display is opened or its position is moved. In step S11, the host computer 10 checks the position of the window after it is opened or moved to detect whether the window is at a proper position for a stereoscopic vision. That is, if the right-eye and left-eye image display areas determined with respect to the screen 7 coincide with the display positions of the respective images in the window 6, as shown in Fig. 6, the host computer 10 determines that the window is at the proper position. If the right-eye and left-eye image display areas determined with respect to the screen 7 do not coincide with the display positions of the respective images in the window 6, as shown in Fig. 7, the host computer 10 determines that the window is at an improper position. Upon determining that the window

is at the proper position, the host computer 10 continues the display state. Otherwise, the flow advances to step S12 to automatically perform fine adjustment of the window position. Although not shown  
5 in the flow chart, if the opened or moved window is not for stereoscopic image display, the flow does not advance to step S11 and the subsequent steps.

A method of detecting the generation or movement of a window and checking its position depends on the  
10 OS, the application, or the like used in the computer. Assume that an application which operates on "Windows 3.1" (trademark), which is an OS available from Microsoft Corporation, is to be created by using Visual Basic Ver.2.0 (trademark), which is an  
15 application development language available from Microsoft Corporation. In this case, a window is recognized as an object called "Form". The generation of a window is defined as an event represented by Form\_Load(), and the movement of a window is defined  
20 as an event represented by Form\_Paint(). If, therefore, a program is created such that when the execution of each event is confirmed, a function for detecting the position of the window (Form) is called, the current position of the window which is moved or generated can  
25 be obtained.

A method of finely adjusting the position of a

window will be described next with reference to  
Figs. 9 and 10. Fig. 9 explains fine adjustment of a  
window position for a vertically striped parallax  
image. Fig. 10 explains fine adjustment of a window  
5 position for a horizontally striped parallax image.

When a vertically striped parallax image is to be  
displayed, the window is moved to the right or left by  
one stripe pitch in the horizontal direction, as shown  
in Fig. 9. In many cases, the period of stripe images  
10 coincides with the minimum pixel pitch of an image  
display surface. In this case, therefore, it suffices  
if the window is moved to the right or left by one  
pixel. With this operation, the reversed stereoscopic  
vision state is corrected to the proper stereoscopic  
15 vision state.

When a horizontally striped parallax image is to  
be displayed, the window is moved up or down by one  
stripe pitch in the vertical direction within the  
screen, as shown in Fig. 10. In many cases, the period  
20 of stripe images coincides with the minimum pixel  
pitch of the image display surface. In this case,  
therefore, it suffices if the window is moved up or  
down by one pixel. With this operation, the reversed  
stereoscopic vision state is corrected to the proper  
25 stereoscopic vision state.

Assume that assignment information determined by

the relative positional relationship with the electronic parallax barrier 103 as a directivity control means and indicating the assignment of positions, on the transmission type liquid crystal display 101, where images for the right and left eyes are to be displayed are stored in the memory of the host computer 10 in advance. The determination processing in step S11 is performed on the basis of this assignment information. The assignment information may be notified from the stereoscopic display apparatus 20 by communication, or may be held in a driver program added to the stereoscopic display apparatus 20.

When a window is automatically moved in this manner, the amount of movement is very small in most cases. For this reason, such movement is hardly recognized by the observer.

As described above, according to the first embodiment, there is provided a stereoscopic display which can automatically maintain a proper stereoscopic vision without attracting <sup>the</sup> observer's attention.

#### <Second Embodiment>

The second embodiment of the present invention will be described next. In the second embodiment as well, the present invention is applied to a stereoscopic display apparatus 20 which allows an

observer to observe a stereoscopic image by using the parallax between the right and left eyes and a computer system including a host computer 10 for controlling the display apparatus.

5           In the first embodiment, a proper stereoscopic vision state is maintained by automatically moving a window upon detection of the window position. In contrast to this, in the second embodiment, a proper stereoscopic vision is maintained by changing the  
10 contents of an image to be displayed after detection of the position of a window.

Fig. 11 is a flow chart showing an operation procedure performed by the host computer in the second embodiment. In step S20, the host computer 10 detects  
15 that a window for stereoscopic image display is opened or its position is moved. Opening or movement of a window is detected in the above manner. In step S21, the host computer 10 checks the position of the window to detect whether the window is at a position where a  
20 proper stereoscopic vision is realized. If the window position is at a proper position, the current state is maintained. If the window position is not at a proper position, the flow advances to step S22 to automatically change the contents of a displayed image.

25           Processing of changing the contents of the displayed image in step S22 will be described in

detail next. Figs. 12 to 16 explain how the contents of the displayed image within the window are changed.

When the displayed image is a vertically striped parallax image, one of the following changing

5 operations is performed.

(1) As shown in Fig. 12, the image in the window is moved to the right by one stripe pitch in the horizontal direction within the screen. Obviously, the image in the window may be moved to the left by one  
10 stripe pitch.

(2) The image is displayed upon interchange of the L and R areas.

In method (1), since the period of stripe images coincides with the minimum pixel pitch of an image  
15 display screen in most cases, the image is moved to the right or left by one pixel. In this case, the position of the window is not changed, but only the image in the window is moved.

When only the displayed image filling the window  
20 is moved, an area without any image data is inevitably displayed. In such a case, this area may be displayed as a solid black area, as shown in Fig. 13.

Alternatively, as shown in Fig. 14, only an area smaller than the original striped image by one stripe  
25 in the horizontal direction is displayed in advance in the window, and the data in the area outside the



window, which has not been displayed, is displayed when the image needs to be moved. In the case shown in Fig. 14, the image in the window is moved to the left.

In method (2), since the left and right images of the striped image are alternately arranged, the image is displayed upon interchanging the left and right stripes.

When, for example, the left-eye image (Fig. 2) and the right-eye image (Fig. 3) are to be synthesized into a striped image, two types of images, i.e., the image in Fig. 4 and the image in Fig. 15, are generated by changing the order of right and left stripes. If, therefore, one of the images is displayed, and a reversed stereoscopic vision state occurs, a proper stereoscopic vision state can be set by interchanging one image and the other image.

When the display image is a horizontally striped parallax image, one of the following changing operations is performed.

(1) As shown in Fig. 16, the image in the window is moved by one stripe pitch in the vertical direction within the screen (up-and-down direction).

(2) The image is displayed upon interchanging the L and R areas.

Since the contents of the changing operations are the same as those in the case of the vertically

striped parallax image, a detailed description thereof will be omitted.

In most cases, the contents of such a displayed image can be automatically changed by slightly moving  
5 the image. Therefore, the observer hardly recognize this movement.

According to this embodiment as well, therefore, there is provided a stereoscopic display which can automatically maintain a proper stereoscopic vision  
10 without attracting <sup>the</sup> observer's attention.

<Third Embodiment>

The third embodiment of the present invention will be described next. In the third embodiment as well, the present invention is applied to a  
15 stereoscopic display apparatus 20 which allows an observer to observe a stereoscopic image by using the parallax between the right and left eyes and a computer system including a host computer 10 for controlling the display apparatus.

20 In the first and second embodiments, a reversed stereoscopic vision is prevented by moving or changing a displayed image. In contrast to this, in the third embodiment, a stereoscopic vision state is maintained by changing the state of a directivity control means  
25 upon detection of the position of a window. The stereoscopic display used in the third embodiment is

therefore designed to actively change the relative positional relationship between the image display surface and the directivity control means. In the parallax barrier scheme, for example, if the barrier unit has a mechanism for allowing the unit to mechanically move while keeping parallel to the screen, such a state change can be made. Alternatively, the electronic parallax barrier may be designed to change the stripe display positions.

Fig. 17 is a flow chart showing a control procedure performed by the host computer in the third embodiment. When the host computer 10 detects in step S30 that a window is opened or moved, the flow advances to step S31. In step S31, if it is determined on the basis of the position of the window after it is opened or moved that the window is a window to be subjected to stereoscopic image display, the host computer 10 checks the position of the window after it is opened or moved, and determines whether the window is at a position where a proper stereoscopic vision is obtained. If it is determined that the window is at the proper position, the host computer 10 continues the current state. Otherwise, the flow advances to step S32 to automatically change the state of the directivity control means.

The state of this directivity control means is

changed as follows.

When the displayed image is a vertically striped parallax image, the directivity control means is moved to the right or left by one pitch of the periodic structure of the directivity control means in the horizontal direction within the screen. Note that the positions of the window and the image are not changed in this case.

When a stereoscopic display which can generate a striped barrier pattern at an arbitrary position on the display, as disclosed in Japanese Patent Laid-Open No. 5-122733, is used, since a directivity control means can be electronically generated at an arbitrary position, the above operation of changing the state of the directivity control means can be performed more easily.

As described above, in the third embodiment, the relative positional relationship between a parallax barrier and a striped parallax image is detected to automatically perform active control on the parallax barrier.

When the displayed image is a horizontally striped parallax image, the directivity control means is moved up or down by one pitch of the periodic structure of the directivity control means in the vertical direction within the screen. The contents of

this changing operation are the same as those in the case of the vertically striped parallax image.

In most cases, the contents of such a displayed image can be automatically changed by slightly moving  
5 the image. Therefore, the observer hardly recognize this movement. According to this embodiment, similar to the first and second embodiments, therefore, there is provided a stereoscopic display which can automatically maintain a proper stereoscopic vision  
10 without attracting <sup>the</sup> observer's attention.

<Fourth Embodiment>

The fourth embodiment of the present invention will be described next. In the first to third  
15 embodiments, the position of a window, the contents of an image, and the state of the directivity control means are changed in accordance with the static window position. In the fourth embodiment, even when the position of a window dynamically changes, a proper stereoscopic vision state is maintained by performing  
20 the above state changing operations.

In general, when the cursor pointer of a mouse is placed on the title bar on the upper portion of a window and moved to a desired position in a clicked state, the window moves together with the cursor  
25 pointer as if the window is restrained by the movement of the mouse. An operation of moving a window together

with the cursor pointer is called dragging. An operation of releasing a window by releasing the button at a proper position after dragging is called dropping.

5           The position of a window dynamically changes in accordance with the movement of the cursor pointer while the window is dragged. This window and the image in the window may be kept displayed during this dragging operation. When, therefore, the image in the  
10 window is a striped parallax image, a reversed stereoscopic vision must also be prevented during dragging of the window by some means. Fig. 18 is a flow chart showing a control procedure for preventing a reversed stereoscopic vision during dragging of a  
15 window. When the start of the movement of a window by dragging is detected in step S41, it is checked in step S42 whether the current position of the window is a position where a proper stereoscopic vision can be realized. If YES in step S42, the flow advances to  
20 step S44.

          If it is determined that the window is at a position where a reversed stereoscopic vision occurs, the flow advances to step S43 to execute a corresponding state changing operation. In this case,  
25 the "corresponding state changing operation" indicates finely changing the window position (first embodiment),

changing the contents of the image in the window  
(second embodiment), or changing the state of the  
stereoscopic (third embodiment) which is described in  
the corresponding embodiment.

- 5           The flow then advances to step S44 to check  
whether the dragging operation is continued. If YES in  
step S44, the flow returns to step S42. If NO in step  
S44, this processing is terminated.

- Although the basic policy of the above processing  
10   does not greatly differ from that in the first to  
third embodiment, it should be noted that detection of  
the position of a window, verification of the window  
position, and a corresponding state changing operation  
are performed at very high speed. This is because, the  
15   position of a window incessantly changes from proper  
stereoscopic vision position to improper positions  
while the window position dynamically changes owing to  
dragging, and the observer cannot continuously obtain  
a proper stereoscopic vision unless a corresponding  
20   state changing operation is performed to prevent a  
reversed stereoscopic vision every time the window  
position is set at an improper position. In this  
embodiment, therefore, the window detection period  
during dragging is set to be very short to complete  
25   verification of the window position and a  
corresponding state changing operation within a period

of time shorter than the above period.

As described above, according to the fourth embodiment, there is provided a stereoscopic display which can automatically maintain a proper stereoscopic vision even while the observer is moving a window.

As described above, according to each embodiment described above, in the computer system including the stereoscopic display apparatus which allows the observer to observe a stereoscopic image by using the parallax between the right and left eyes, and the host computer for controlling the display apparatus, when several windows are opened on the screen, and stereoscopic images are displayed in the windows, the observer can always have a proper stereoscopic vision in a given window even if the position of the window changes.

In both the parallax barrier scheme and the lenticular scheme, position pixel unit width on the image display surface corresponds to the eye width of the observer. Since an image having a size of several  $\mu\text{m}$  is enlarged into an image having a size of several cm, a one-pitch shift of the displayed image as in the above embodiments greatly influences the optimal observation position. That is, adjustment by such a one-pitch shift is very effective.

Note that the present invention may be applied to



either a system constituted by a plurality of equipments (e.g., a host computer, an interface device, a reader, a printer, and the like), or an apparatus consisting of a single equipment (e.g., a copying  
5 machine, a facsimile apparatus, or the like).

The objects of the present invention are also achieved by supplying a storage medium, which records a program code of a software program that can realize the functions of the above-mentioned embodiments to  
10 the system or apparatus, and reading out and executing the program code stored in the storage medium by a computer (or a CPU or MPU) of the system or apparatus.

In this case, the program code itself read out from the storage medium realizes the functions of the  
15 above-mentioned embodiments, and the storage medium which stores the program code constitutes the present invention.

As the storage medium for supplying the program code, for example, a floppy disk, hard disk, optical  
20 disk, magneto-optical disk, CD-ROM, CD-R, magnetic tape, nonvolatile memory card, ROM, and the like may be used.

The functions of the above-mentioned embodiments may be realized not only by executing the readout  
25 program code by the computer but also by some or all of actual processing operations executed by an OS

(operating system) running on the computer on the basis of an instruction of the program code.

Furthermore, the functions of the above-mentioned embodiments may be realized by some or all of actual  
5 processing operations executed by a CPU or the like arranged in a function extension board or a function extension unit, which is inserted in or connected to the computer, after the program code read out from the storage medium is written in a memory of the extension  
10 board or unit.

As has been described above, according to the present invention, the position of a striped parallax image as a stereoscopic image displayed in a window can be set at a position suited to the display apparatus.

15 According to the present invention, therefore, when several windows are opened on the screen, and images are displayed in the windows as in the case of images handled in the computer, the observer can always have a proper stereoscopic vision in a given window even if the  
20 position of the window changes.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific  
25 embodiments thereof except as defined in the claims.